

SUPPORT FOR THE AMENDMENT

This Amendment amends Claims 1-3. Support for the amendments is found in the specification and claims as originally filed. In particular, support is found in the specification at least at page 5, line 16 and page 9, lines 9-10 ("crystal structure"). No new matter would be introduced by entry of these amendments.

Upon entry of these amendments, Claims 1-7 will be pending in this application. Claims 1, 2, 3, 4, 5, and 6 are independent.

REQUEST FOR RECONSIDERATION

Applicants respectfully request entry of the foregoing and re-examination and reconsideration of the application, as amended, in light of the remarks that follow.

Applicants thank the Examiner for the indication in the Office Action at page 2, line 22 that "Claims 4-7 are allowed".

The present invention provides a phosphorescent phosphor having excellent afterglow characteristics when excited under low illumination. Specification at page 1, lines 3-5. The phosphorescent phosphor comprises a compound expressed by MAl_2O_4 as a matrix in which M comprises at least two selected from Sr, Ba and Ca, and Eu and Dy are doped in the matrix as activators. Specification at page 4, lines 9-15; page 9, line 19-24; page 15, lines 1-7. A ratio of $\text{Al}/(\text{M}+\text{Eu}+\text{Dy})$ ranges from 2.1 to 2.9. Specification at page 4, lines 19-22; page 10, lines 3-6; page 15, lines 13-16. As a result, the crystal structure is distorted to facilitate formation of a trap by making the ratio of Al greater than the stoichiometric ratio of 2.0 in MAl_2O_4 . Specification at page 5, lines 13-18; page 10, line 23 to page 11, line 1; page 16, lines 10-15. Therefore initial afterglow luminance characteristics under the excitation condition of low illumination are improved, resulting in afterglow luminance characteristics

superior to those of conventional phosphorescent phosphors. Specification page 5, lines 18-22; page 11, lines 1-5; page 16, lines 15-19.

Claims 1-3 are rejected under 35 U.S.C. § 112, second paragraph, because the claims recite a "phosphorescent phosphor comprising a compound expressed by MAl_2O_4 as a matrix ... , europium (Eu) doped to said matrix ..., and dysprosium (Dy) doped to said matrix ..." and "a ratio of aluminum (Al) ranging from 2.1 to 2.9 in terms of a molar ratio relative to a total mole number of the metal elements expressed by M, europium (Eu) and dysprosium (Dy)". The specification is objected to for containing similar language.

However, it is well known in the art that:

A phosphor is composed of a host crystal, or matrix, and a small amount of activator(s). The common representation of a phosphor formula is exemplified by $\text{Zn}_2\text{SiO}_4\text{:Mn}(0.02)$, where the first part tells us that the matrix is Zn_2SiO_4 , and the last that 0.02 mol manganese activator was blended per 1 mol of matrix in the raw material mixture. See, e.g., Phosphor Handbook, page 318 (copy attached).

As discussed above, the specification discloses that the phosphorescent phosphor of the present invention comprises a compound having a MAl_2O_4 crystal structure as a matrix, which is doped with Eu and Dy as activators. The specification discloses that the crystal structure is distorted by the addition of Al to enhance the properties of the phosphorescent phosphor of the present invention.

To clarify that the "compound" of independent Claims 1, 2 and 3 does not have a fixed stoichiometry of MAl_2O_4 , Claims 1, 2, and 3 are amended to recite "a compound ~~expressed by~~ having a MAl_2O_4 crystal structure as a matrix".

Applicants submit that Claims 1-3 meet the requirements of 35 U.S.C. § 112, second paragraph. Thus, the rejection and objection should be withdrawn.

In view of the foregoing amendments and remarks, Applicants respectfully submit that the application is in condition for allowance. Applicants respectfully request favorable consideration and prompt allowance of the application.

Should the Examiner believe that anything further is necessary in order to place the application in even better condition for allowance, the Examiner is invited to contact Applicants' undersigned attorney at the telephone number listed below.

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Attached: Phosphor Handbook, pages 317-318

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chapter four — section one

Methods of phosphor synthesis and related technology

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4.1 General technology of synthesis

4.1.1 Outline of synthesis processes

Almost all phosphors are synthesized by solid-state reactions between raw materials at high temperatures.* Figure 1 shows the general concept of the synthesis process. First, the high-purity materials of the host crystal, activators, and fluxes are blended, mixed, and then fired in a container. As the product obtained by firing is more or less sintered, it is

* Single crystals and vacuum-deposited thin films are sometimes used as radioluminescent phosphors. (Chapter 7). Some electroluminescent devices have thin film- or epitaxially grown luminescent layers (Chapter 9).

crushed, milled, and then sorted to remove coarse and excessively crushed particles. In some cases, the product undergoes surface treatments.

4.1.2 Purification of raw materials

As small amounts of impurities sometimes change phosphor characteristics drastically, raw materials must be purified very carefully. Some typical cases are described below.

In case of the raw materials of zinc sulfide phosphors, iron-group ions have to be thoroughly removed. Two methods are employed for material purification,¹ namely the alkali process and the acid process. In the first stage of the latter, which is more frequently used, high-purity zinc oxide is dissolved in H_2SO_4 . The solution is then brought into contact with metallic zinc to reduce iron and copper ions to the metallic state for removal. Then, H_2O_2 is added to oxidize the remaining ferrous ions to ferric ions. The ferric ions are precipitated with NH_4OH as $\text{Fe}(\text{OH})_3$ and removed. The zinc ions in the solution are then precipitated as ZnS by supplying H_2S to the solution (See 6.2).

Calcium halophosphate phosphor, $\text{Ca}_5(\text{PO}_4)_3(\text{F}, \text{Cl})\text{:Sb}^{3+}, \text{Mn}^{2+}$, one of the most important lamp phosphors, is usually synthesized from CaHPO_4 , CaCO_3 , CaF_2 , CaCl_2 , Sb_2O_3 , and MnCO_3 . Among these, CaHPO_4 and CaCO_3 provide 90% of the weight of the raw material mixture. The purification process of these two components is shown in Figure 2. The luminescence efficiency of the halophosphate phosphor is seriously affected not only by the presence of heavy metals, but also by Na. In commercial materials, heavy metals are controlled to within a few ppm, and Na to within 5 to 10 ppm.

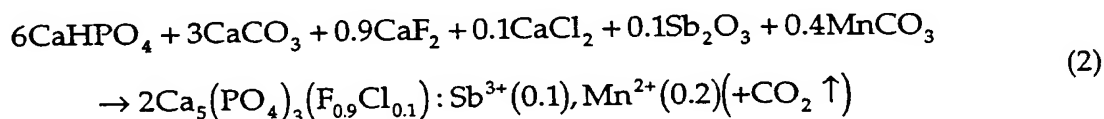
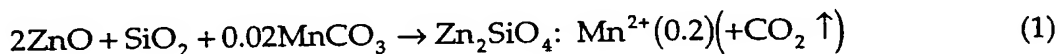
In the rare-earth raw materials, separation of a single rare-earth ion from the others is most important. Figure 3 shows a typical refining process of a rare-earth ore.² In the case of Y_2O_3 , the most frequently used rare-earth compound, rare earths other than Y are kept below 10 ppm, and the total amount of heavy metals below 10 ppm.

4.1.3 Synthesis

4.1.3.1 Matrix synthesis and activator introduction

A phosphor is composed of a host crystal, or matrix, and a small amount of activator(s). The common representation of a phosphor formula is exemplified by $\text{Zn}_2\text{SiO}_4\text{:Mn}(0.02)$, where the first part tells us that the matrix is Zn_2SiO_4 , and the last that 0.02 mol manganese activator was blended per 1 mole of matrix in the raw material mixture.

There are two different kinds of reactions in phosphor synthesis. In the first one, activator ions are introduced into an existing host material. A typical example of this kind is zinc sulfide phosphors, where following particle growth of the host crystal, diffusion of the activators into the ZnS lattice takes place. In the second scheme, host material synthesis and activator incorporation proceed simultaneously during firing, as shown in the following examples:



Activators are added to raw material blends in the form of compounds (Sb_2O_3 and MnCO_3 in the above example), or as a component of a co-precipitate. A typical example for the latter is $\text{Y}_2\text{O}_3\text{:Eu}^{3+}$. In this case, synthesis by firing a physical mixture of Y_2O_3 and Eu_2O_3